
Space Weather Technical Forecast

Issued on Wednesday, 26 July 2023 at 01:26 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: CME arrived 25 Jul, with G1/Minor storms likely day 1 (27 Jul). Chance R1/R2 blackouts throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with two M-flares and ten sunspot regions. Peak flare was an M1.6 from AR3380 at 25/2116 UTC. This is a relatively small region in the southeast disc, dominated by a central positive umbral region with surrounding small mixed polarity spots leading to some moderate complexity, but no significant growth recently observed. The other flare was an M1.5 from AR3376 peaking 25/0203 UTC. This region has seen some significant growth, however it is now approaching the northwest limb and its complexity is becoming difficult to assess. The remaining regions remained stable or decayed slightly.

No Earth-directed CMEs were observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: CME arrival occurred at L1 at 24/2153 UTC with solar winds speeds, as observed by ACE, increasing from background values of around 370-390km/s to becoming variable between 500-560 km/s. Density also rose from background levels, with ACE recording 15 ppcc. Interplanetary magnetic field (IMF), Bt, was initially weak and steady at 5-7 nT but rose to peak near 17nT at 24/2156 UTC, before easing to vary 6-10nT. The north-south component was variable ranging from +6 to -6nT, but dropped to -12nT with the CME arrival, before quickly becoming positive, peaking 15nT. A turbulent variation then occurred between north and south, although overall strength in the north-south direction decreased. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3), but with a G1/Minor Storm interval observed 25/2100-2400 UTC with the CME arrival.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained persisted around 1.5 to 2.5 pfu after the enhancement by the far-side event on 24 Jul, well below the S1 Minor Storm threshold, before falling nearer to background at 25/1730 UTC. GOES16 high energy (greater than 2MeV) electron flux was Background to Moderate throughout, with the associated 24-hour integrated fluence persisting below the Active threshold. A slight rising trend was observed, with 5.82e6 total pfu at 26/0000 UTC

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with isolated M-class flares likely.

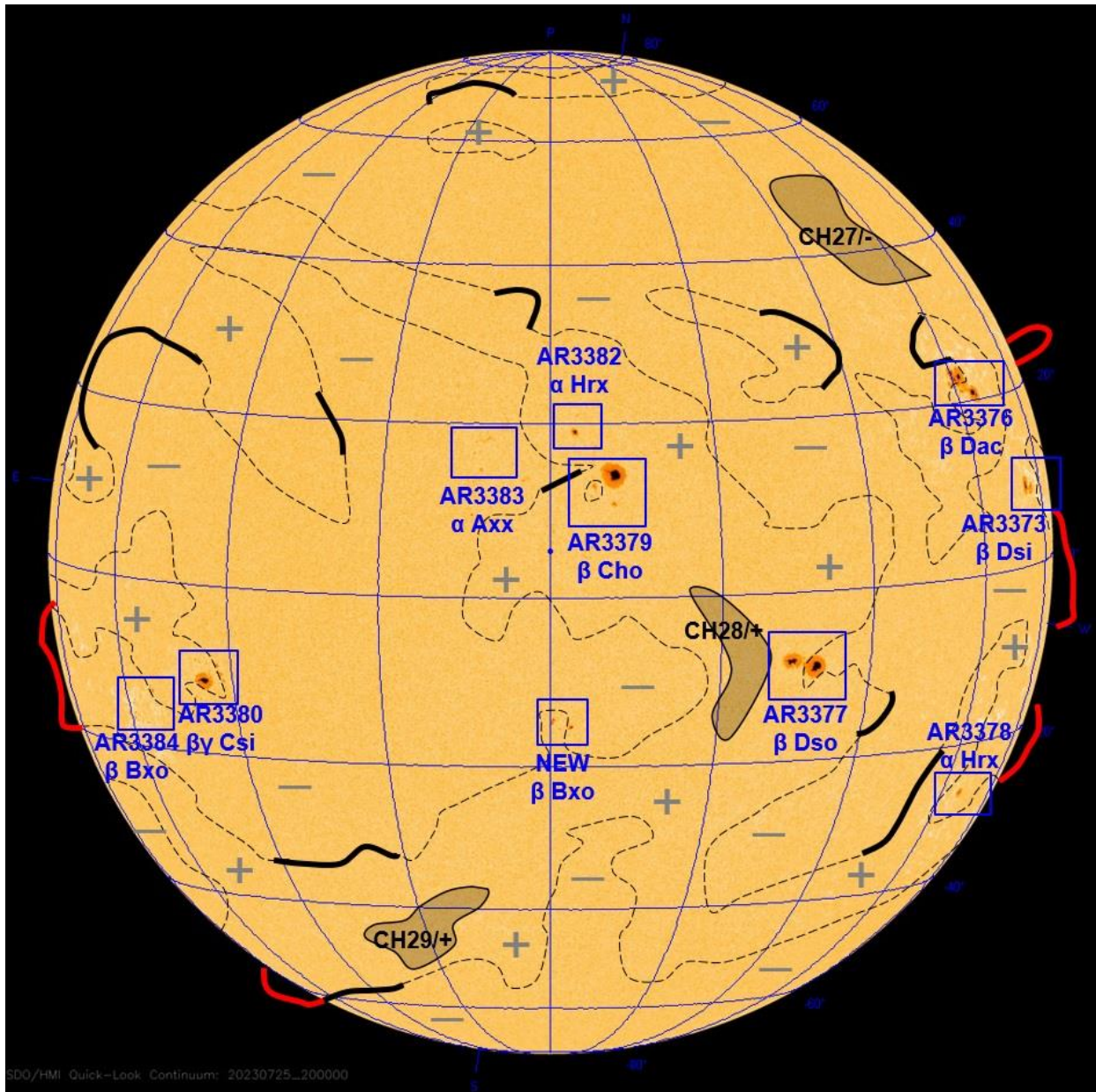
Solar Wind / Geomagnetic Activity: CME arrival on 24/2153 UTC is potentially the very early arrival of a CME forecast to arrive later on day 1 or early day 2. This is from 23 Jul due to the C7 flare of AR3376. There are other potential sources of the enhancement observed however, and so a further arrival later day 1 or early day 2 cannot be completely ruled out. Otherwise a weak coronal hole HSS may arrive day 3 into 4 (28-29 Jul) however this is low confidence. Ongoing CME effects are likely to give Active to G1 Minor Storm intervals at first day 1 (26 Jul). Any further enhancement, or significant magnetic cloud will give a chance of further G1 Minor Storms. There is a slight chance of isolated G2 Moderate storms. As CME influence recedes, likely during day 2 (27 Jul), mainly Quiet to Unsettled conditions are expected, rising again to

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Unsettled to Active, with a slight chance of G1 Minor Storms with any coronal hole enhancement day 3 or 4 (28-29 Jul).

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux is expected to continue declining towards background. There remains a slight chance of proton flux increasing from any further significant flares that occur. The high energy (greater than 2MeV) electron flux is expected to persist at mainly background levels, but with a chance of becoming more persistently moderate, perhaps rising to high once any CME influence recedes day 2 (27 Jul) onward.

Figure 1. Solar Analysis Valid 25/2000 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A CME arrived at L1 at 25/2153 UTC. This is potentially the early arrival of the CME from the long period C7.4 flare from AR3376 on 23/1457 UTC. However this was forecast to give a likely glancing impact either later day 1 or early day 2 (26-27 Jul), so would be a much earlier arrival than anticipated. There was however a broad shock ahead of this CME, and the enhancement observed could be associated with any material within this.

Alternatively, there is another CME which was forecast to miss Earth at around the time of the CME arrival. This was from the M3 flare of AR3372 on 22 Jul off the northwest disc, which was expected to pass ahead of Earth. This is considered an unlikely source for this CME, but result in low confidence for the geomagnetic forecast through day 1 (26 Jul) with a further enhancement possible.

Once any CME influence does ease day 2 (27 Jul) and beyond, the next enhancement is expected to be from CH28/+. This is a weak and indistinct feature in the centre disc, with any associated enhancement low confidence and likely limited, most likely occurring day 3 (28 Jul) and into day 4 (29 Jul) as indicated by enlil.

Ongoing CME effects are likely to give Active to G1 Minor Storm intervals at first day 1 (26 Jul). Any further enhancement, or significant magnetic cloud will give a chance of further G1 Minor Storms. There is a slight chance of isolated G2 Moderate storms. As CME influence recedes, likely during day 2 (27 Jul), mainly Quiet to Unsettled conditions are expected, rising again to Unsettled to Active, with a slight chance of G1 Minor Storms with any coronal hole enhancement day 3 or 4 (28-29 Jul).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	75	20	5	5
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/1915	Partial	AR3376 C8.8	NW	735 km/s	27/0000 UTC	Low confidence in arrival time. Glancing impact May be the arrival observed.



Figure 2a: Current Solar winds observed by DSCOVR/ACE

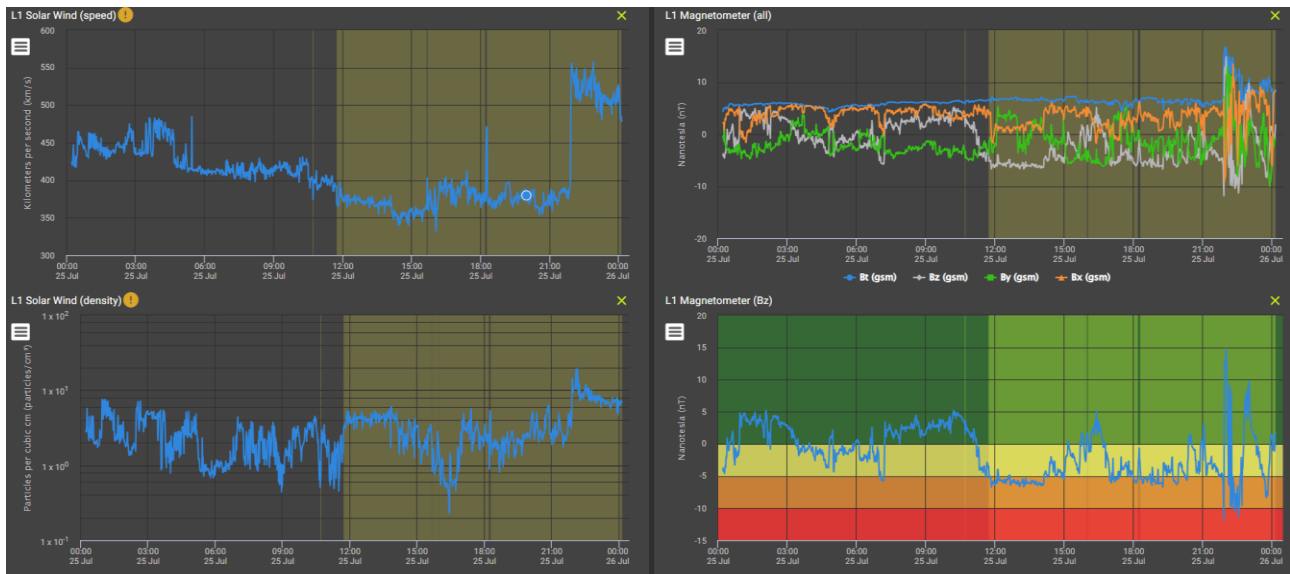


Figure 2b: Observed Kp (from BGS)

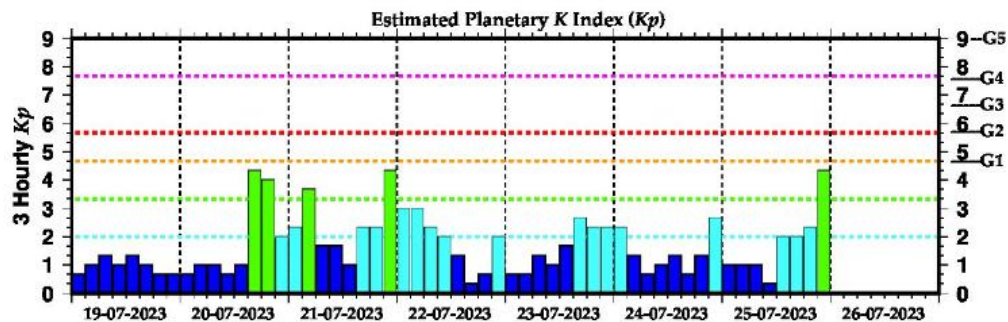


Figure 2c: Observed Hartland H-field

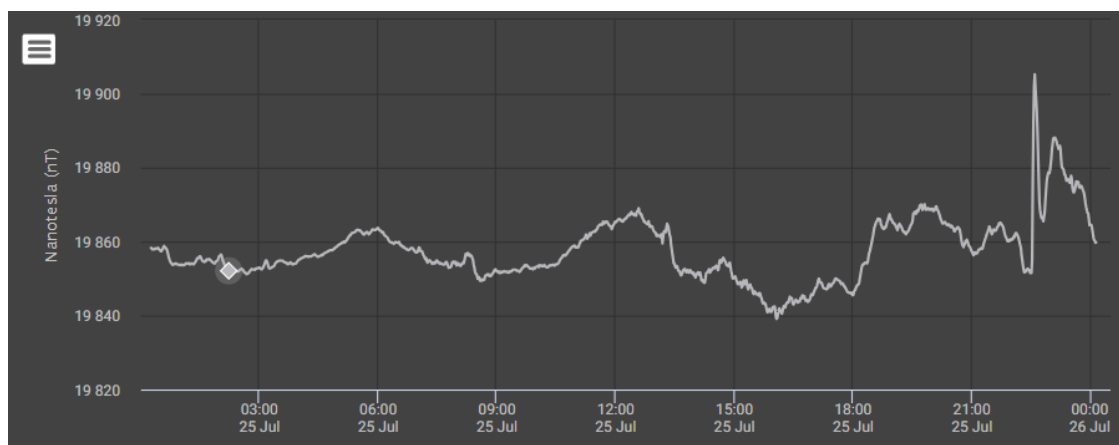
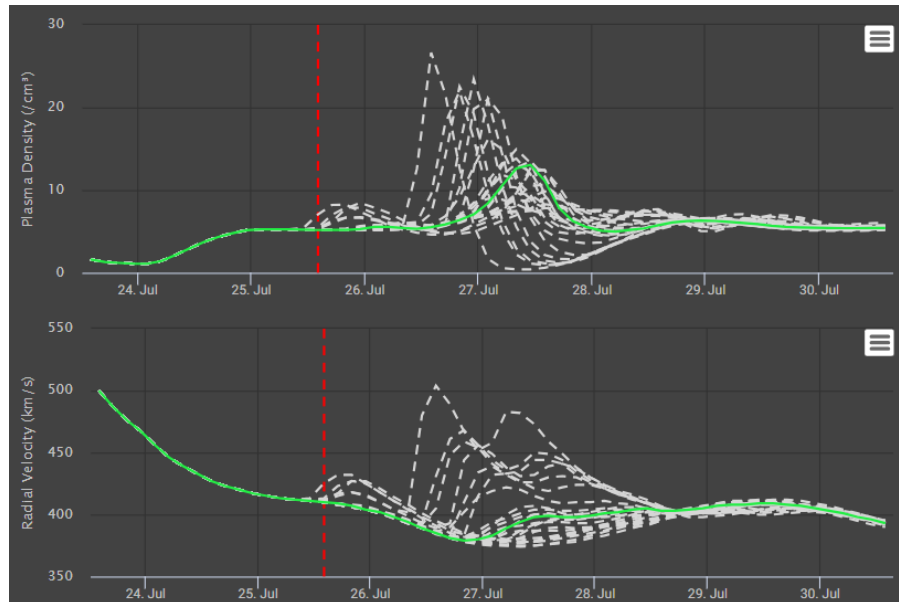
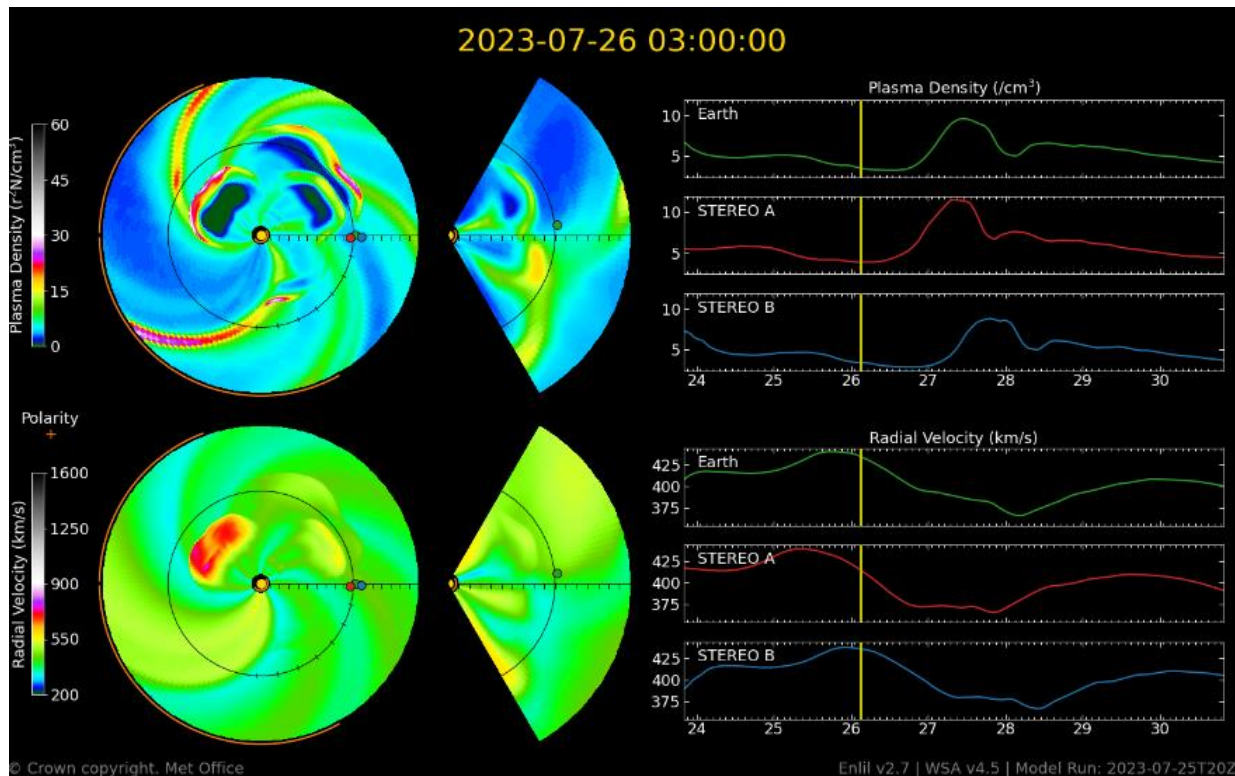


Figure 2d: Enlil and Ensemble, showing missing CME passing earlier, with a couple of ensemble members hitting. The previously expected arrival of CME then occurs later on day 1-2. Low confidence which CME has arrived at this stage.



Radio Blackouts - X-Ray Flares:

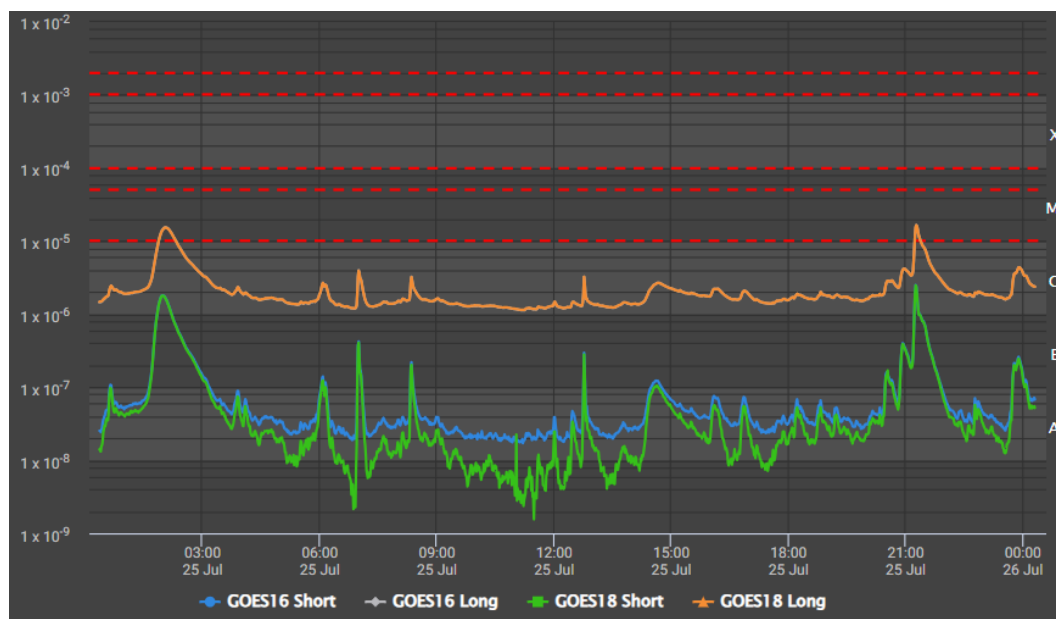
Solar activity has been Moderate over the past 24 hours with two M-flares observed, with Low to Moderate activity expected to continue. Peak flare was an M1.6 from AR3380 at 25/2116 UTC. This is a relatively small region in the southeast disc, dominated by a central positive umbral region with surrounding small mixed polarity spots leading to some moderate complexity.

The other flare was an M1.5 observed from AR3376 peaking at 25/0203 UTC. This region has seen some significant growth in the last 24 hours, however it is now approaching the northwest limb leading to difficulty to assess. Given its compact structure and ongoing growth this region is the most likely source of significant flares.

There are total of ten sunspot regions on the disc, however the other regions are generally simpler and either stable or decaying. The main exceptions are AR3379 in the central disc, which has a large main spot and potential for further growth with any surrounding small spots and a new region developing in the south-centre disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	50	40
Very Active	R3 to R5 X Class	No	10	10	5	5

Figure 3: GOES 16/18 X-ray Flux

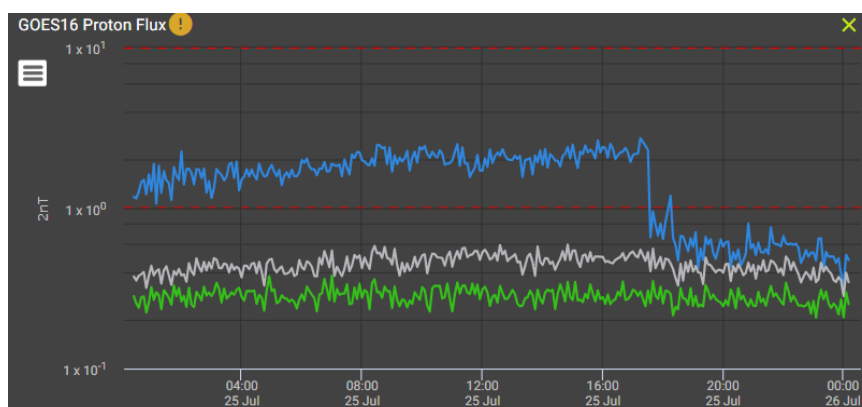


Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 became enhanced on 24 Jul, but below the S1 level, due to a large far-sided eruption, but have now declined to background. There is a slight chance of further enhancements given any large flares, primarily from AR3376 or any of the other regions on the western disc.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	10	5	5
Very Active	$\geq \text{S3}$ *	No	1	1	1	1
* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

Figure 4: GOES16 10MeV, 50 MeV and 100 MeV proton flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electrons (greater than 2MeV) are at Background to Moderate levels. Recent CME arrival has the potential to charge the Van Allen Belts sufficiently to being more persistent Moderate, perhaps occasionally High flux at GEO, most likely once solar wind pressure eases day 2 onward (27 Jul), depending on any further CME enhancement. Confidence remains low however due to the potential for further enhancements, including the arrival of a weak coronal hole fast wind expected either day 3 or 4 (28-29 Jul).

The associated 24-hour electron fluence is most likely to remain below the Active ($1\text{e}8$ integrated pfu) threshold throughout the period, albeit with a rising trend due to any increased flux from the CME arrival. There is a slight chance that this may result in Active fluence (above the $1\text{e}8$ total pfu threshold) by the end of day 2 (27 Jul). REFM is giving good guidance of expected fluence at first, however this currently doesn't take account of the recent CME arrival, so should be used with caution.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	20	20	20
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: GOES-16 Electron Flux and associated 24 hr Fluence with REFM

